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Waterproofed: new cable testing, standard for FPV

28 April 2021

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Cable reliability considerations and electrical issues in Floating Solar – Experiences from 5 years' of operation of the FPV testbed in Singapore

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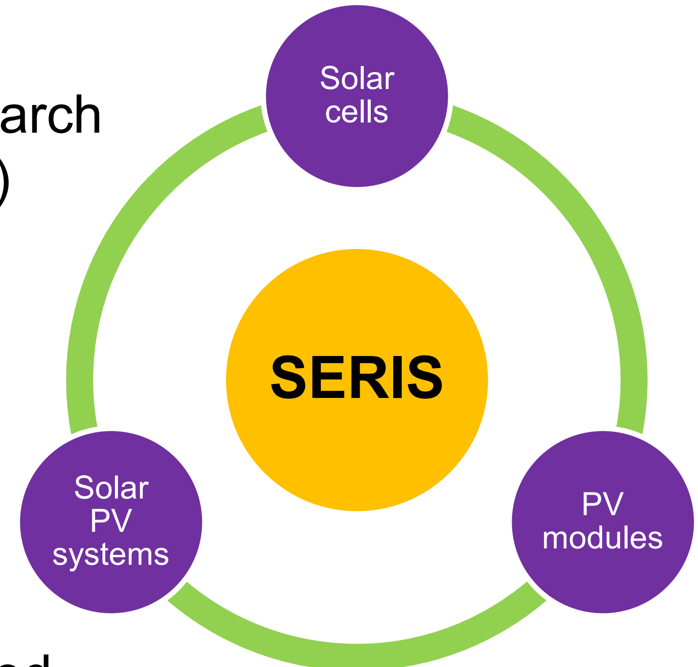
28 April 2021

SERIS is a research institute at the National University of Singapore (NUS). SERIS is supported by NUS, the National Research Foundation Singapore (NRF), the Energy Market Authority of Singapore (EMA) and the Singapore Economic Development Board (EDB).

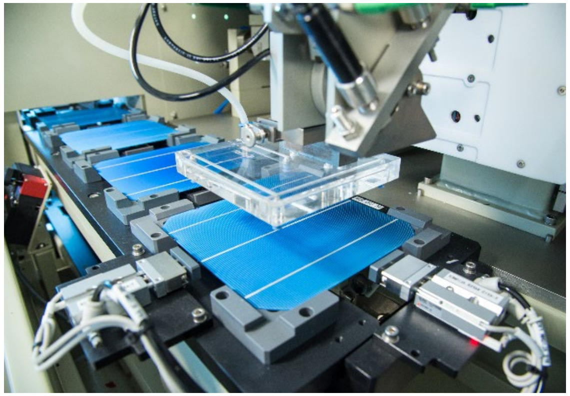
SERIS

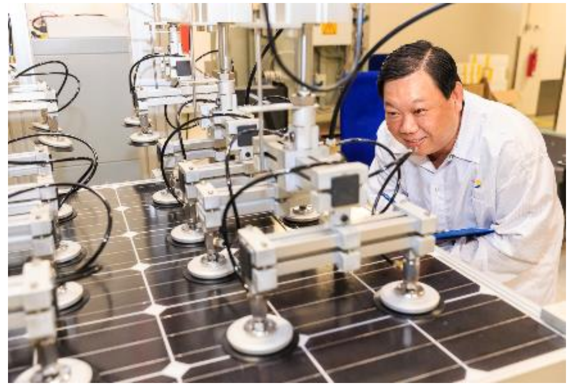
Solar Energy Research Institute of Singapore

- National Lab founded at NUS in 2008; supported by NUS, NRF, EMA & EDB
- Focuses on applied solar energy research (solar cells, PV modules, PV systems)
- > 120 staff & PhD students; state-of-the-art labs, ISO certified (9001, 17025)
- Close collaborations with industry & government agencies
- Strategic priorities: To develop & commercialise solar technologies suited for urban and tropical applications, and support industry development and the energy transformation towards higher solar adoption



Main R&D areas of SERIS





Solar cells:

- Perovskite/silicon tandem solar cells
- Next-generation industrial solar cells
- Characterisation & simulation

PV modules:

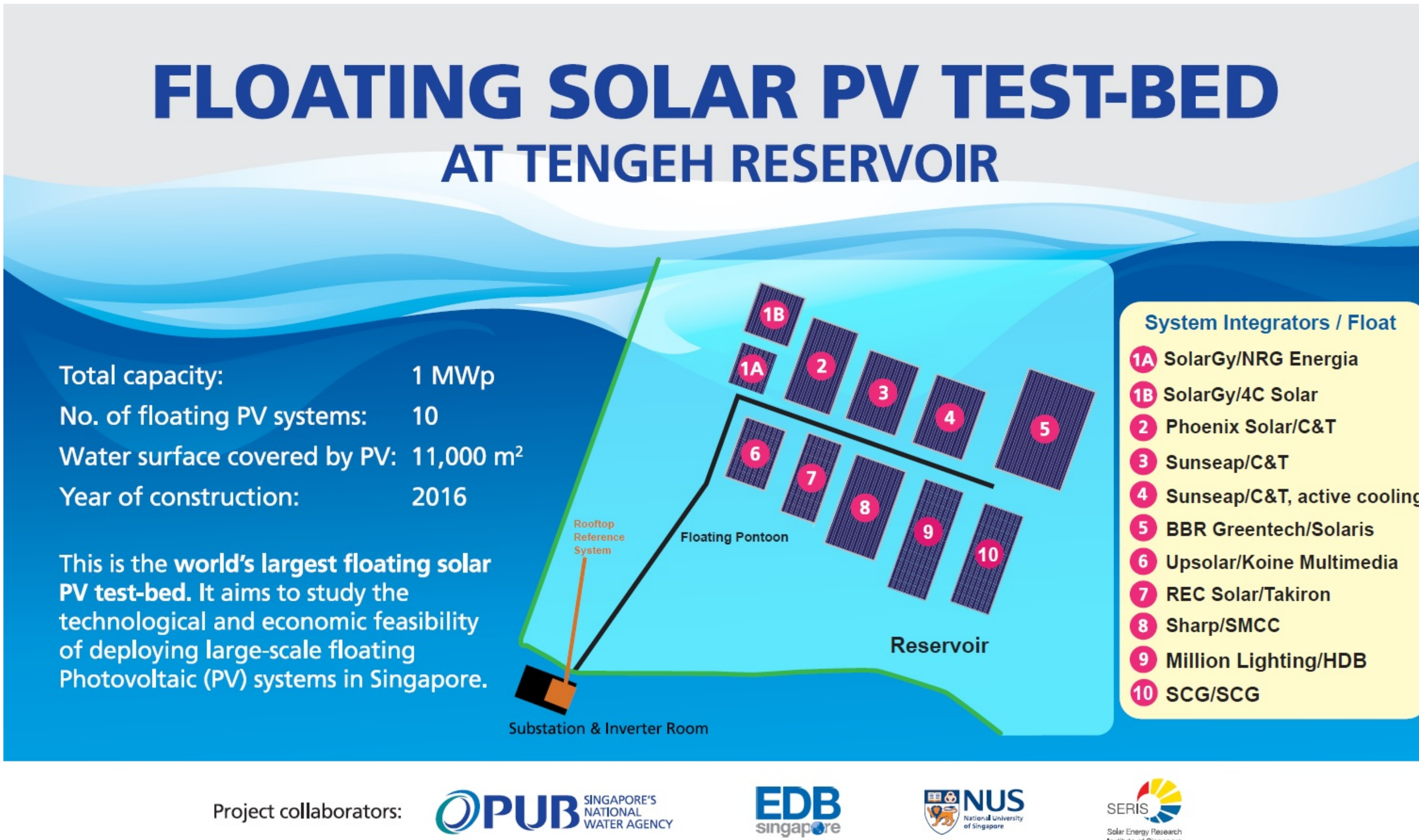
- Module development
- Module testing (indoor & outdoor)
- Characterisation & simulation
- Module reliability studies, failure root cause analysis
- Module recycling

Solar PV systems:

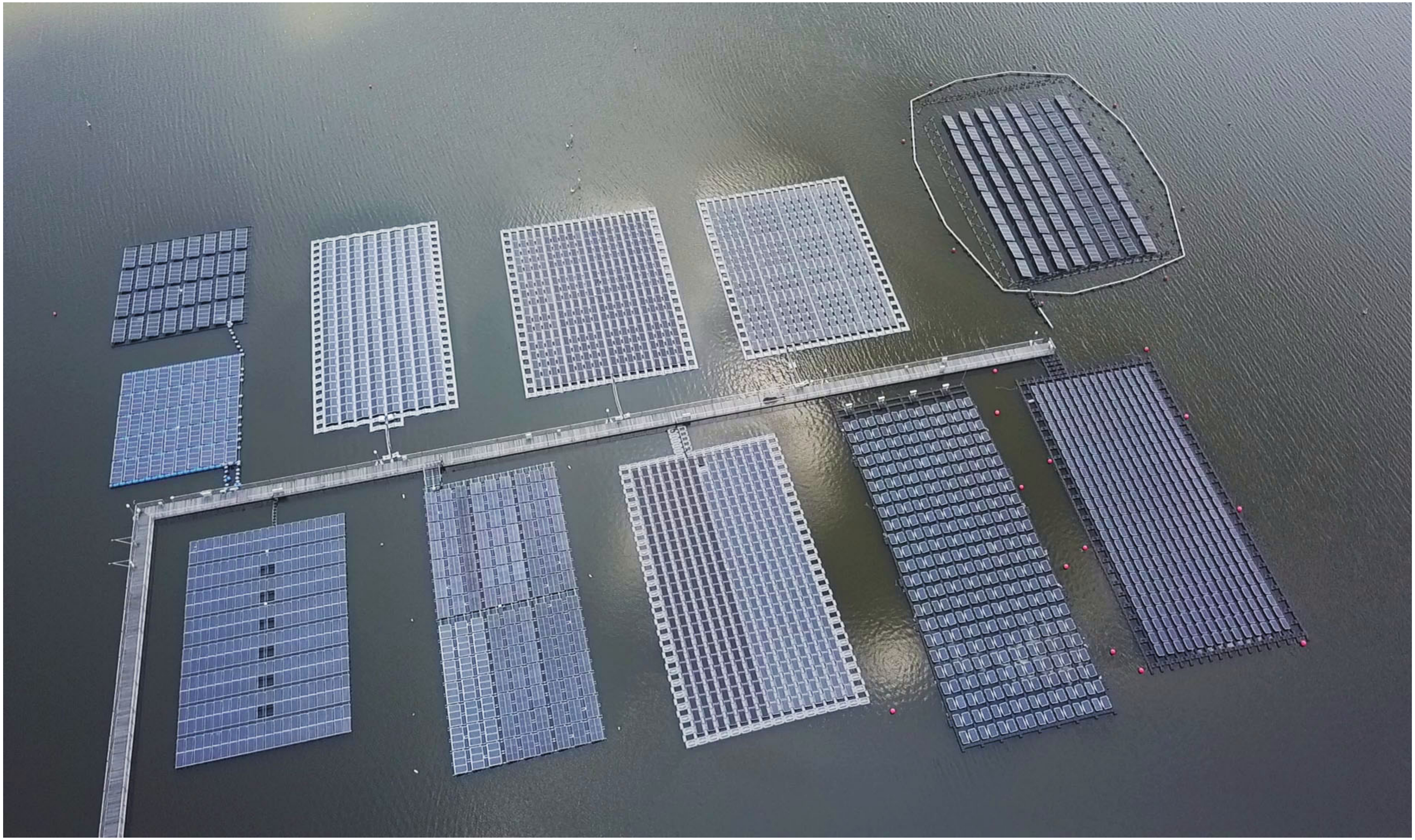
- System technologies, incl. **Floating solar**
- PV grid integration
- Solar potential & energy meteorology
- Urban Solar, incl. BIPV
- Quality assurance of PV systems
- Solarisation of Singapore

The Singapore FPV Testbed

- Total capacity ~ 1 MWp



Floating PV Systems



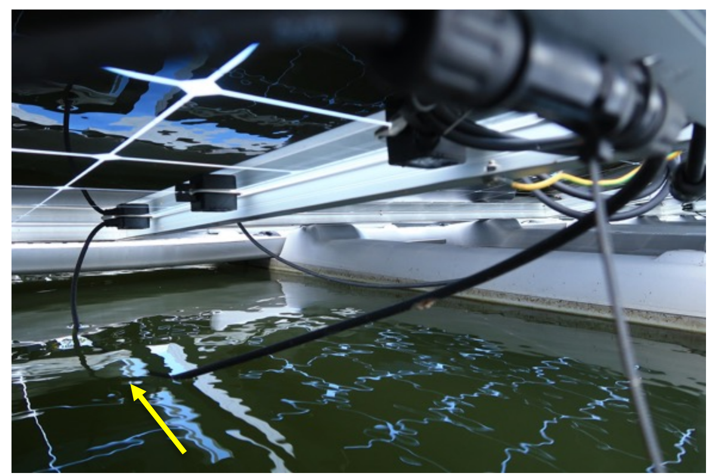
Testbed design and objectives

- ❑ Large scale FPV testbed
- ❑ Side-by-side comparison of major commercial FPV technologies
- ❑ Detailed monitoring
  - ➢ Environment
  - ➢ Energy yield
  - ➢ Module temperature
  - ➢ Bi-facial module
  - ➢ Active cooling
- ❑ Economics, LCOE

Issue 1: Cables touching water

DC module and string cables

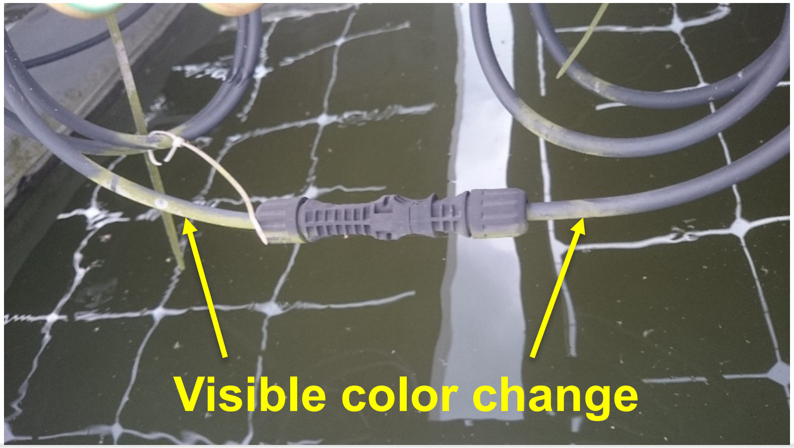
- Causes
  - Low clearance from water surface as well as mismatch in module cable length compared to floats dimension
  - Wave amplitudes due to wind or boat movements
- Consequences
  - Degradation (corrosion) of DC cables and module connectors
  - Possible leakage and low insulation resistance.

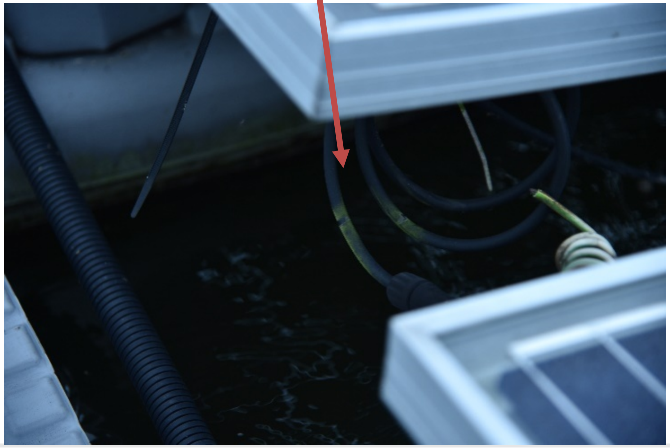


Issue 1: Cables touching water

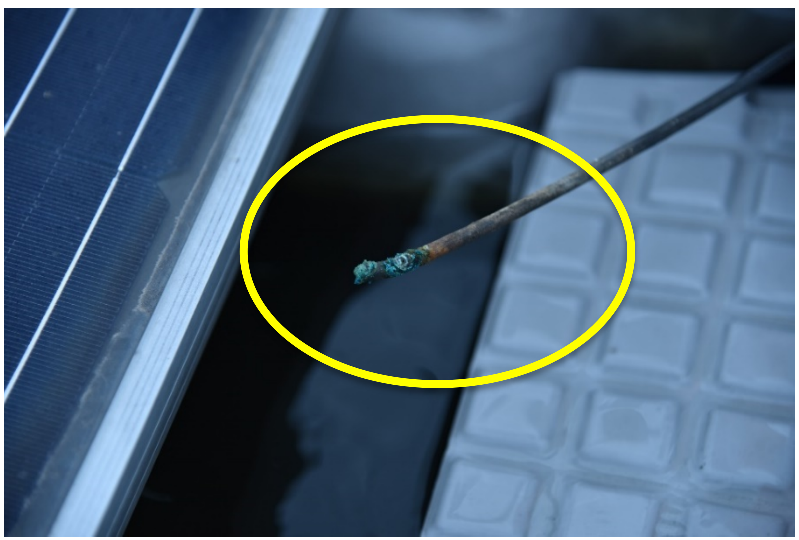
DC module and string cables

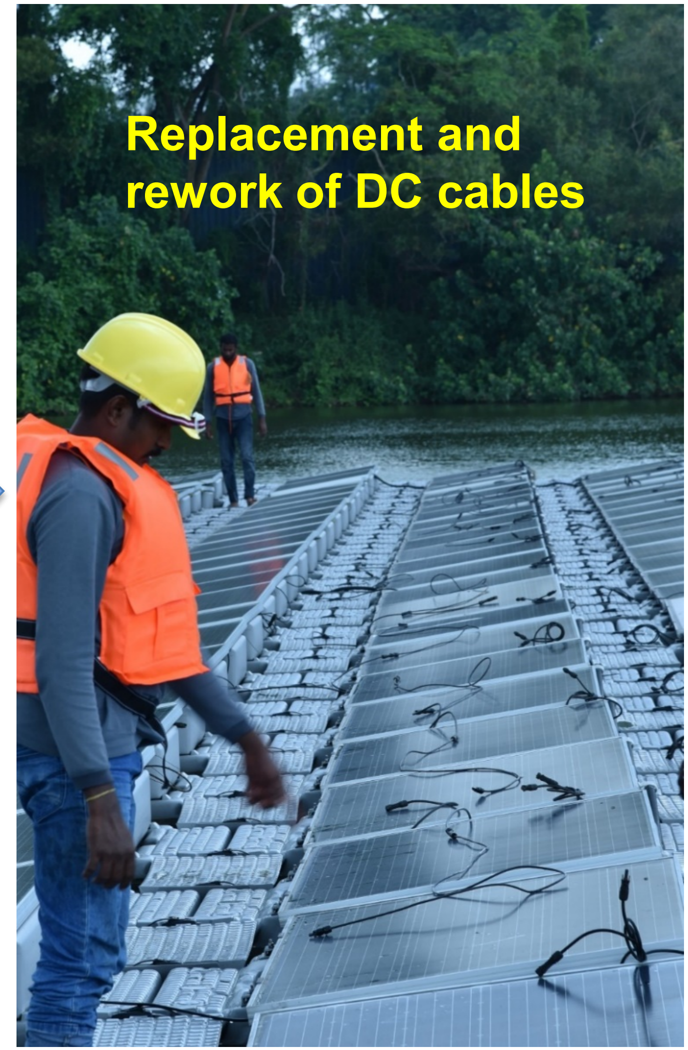
- ❑ Insulation degradation is observed.





Degraded and damaged cables



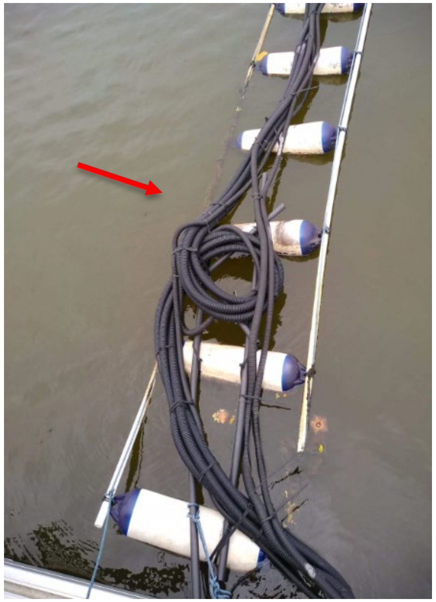


Issue 2: Cable management

Required to mitigate impacts from mechanical movements

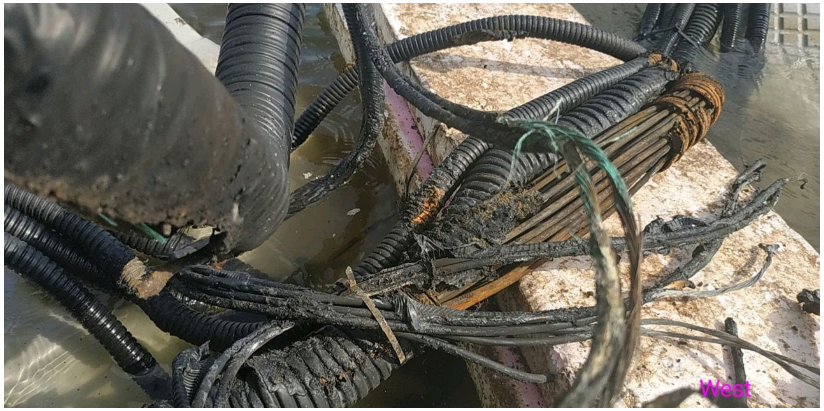
Cabling from FPV islands to shore/inverters often submerged in water

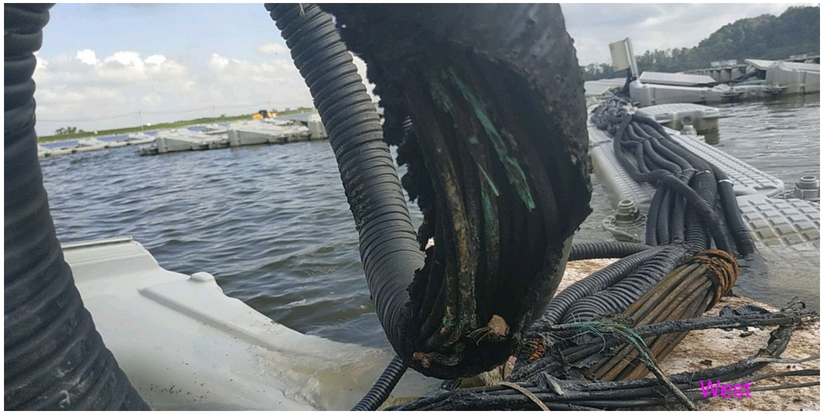
- ❑ Causes: Slackness needed to accommodate platform movement
- ❑ Consequences: Risk of electrical safety, arcing, fire hazard and leakage path to current



Issue 2: Cable management

Required to mitigate impacts from mechanical movements





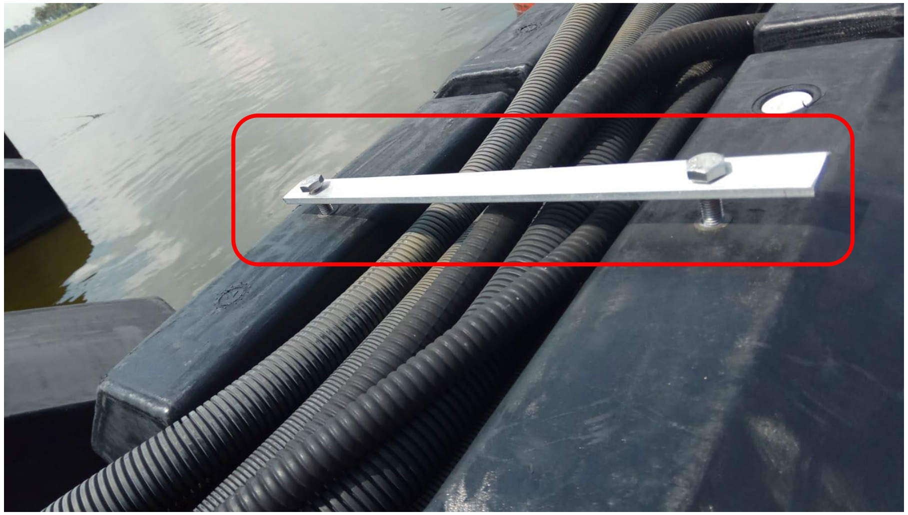
- ❑ Excessive cable slackness results in cables and the cable conduits getting submerged in water intermittently.
- ❑ This results the degradation of sheath / cladding and that can further lead to the possibility of electrical leakages, arcing or a fire hazard.

Issue 2: Cable management

Required to mitigate impacts from mechanical movements

Abrasion of sharp edges of the cable ties or cable fasteners (like the metal guide plate shown below) on the cables

- ❑ Causes: Lack of slackness in the cable run to accommodate for movements and inappropriate usage of cable ties / fasteners
- ❑ Consequences: Risk of electrical safety, arcing, fire hazard and leakage path to current



Issue 2: Cable management

Required to mitigate impacts from mechanical movements

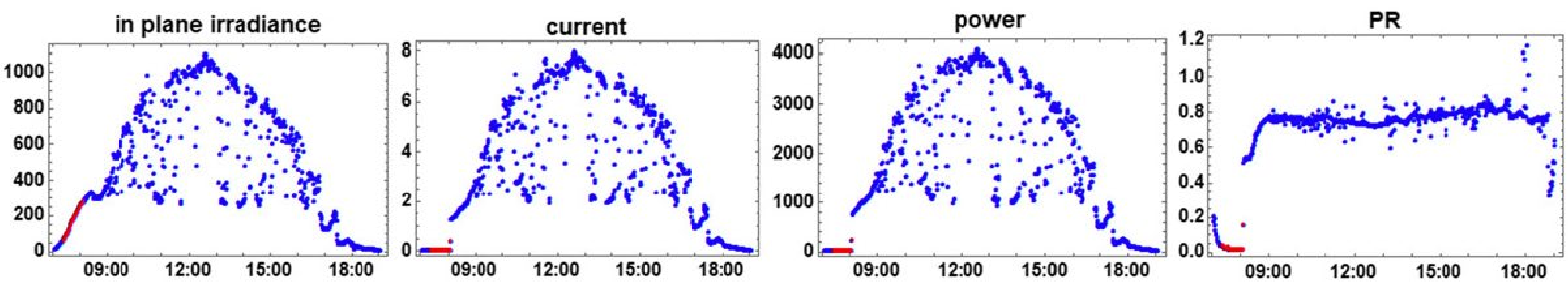
- ❑ Conduit opening allows rainwater to enter

- ❑ Result: Permanent exposure to water, possible cable degradation

Issue 3: Insulation Resistance

Reduced insulation resistance can lead to power loss

- Insulation faults observed for some systems
  - The insulation resistance (R_{iso}) is low for some floating PV strings.
  - Inverters measure R_{iso}. When R_{iso} does not meet the preset threshold, inverters do not start.
  - Result: inverters start late (till the R_{iso} limit is passed) and thus loss of energy.

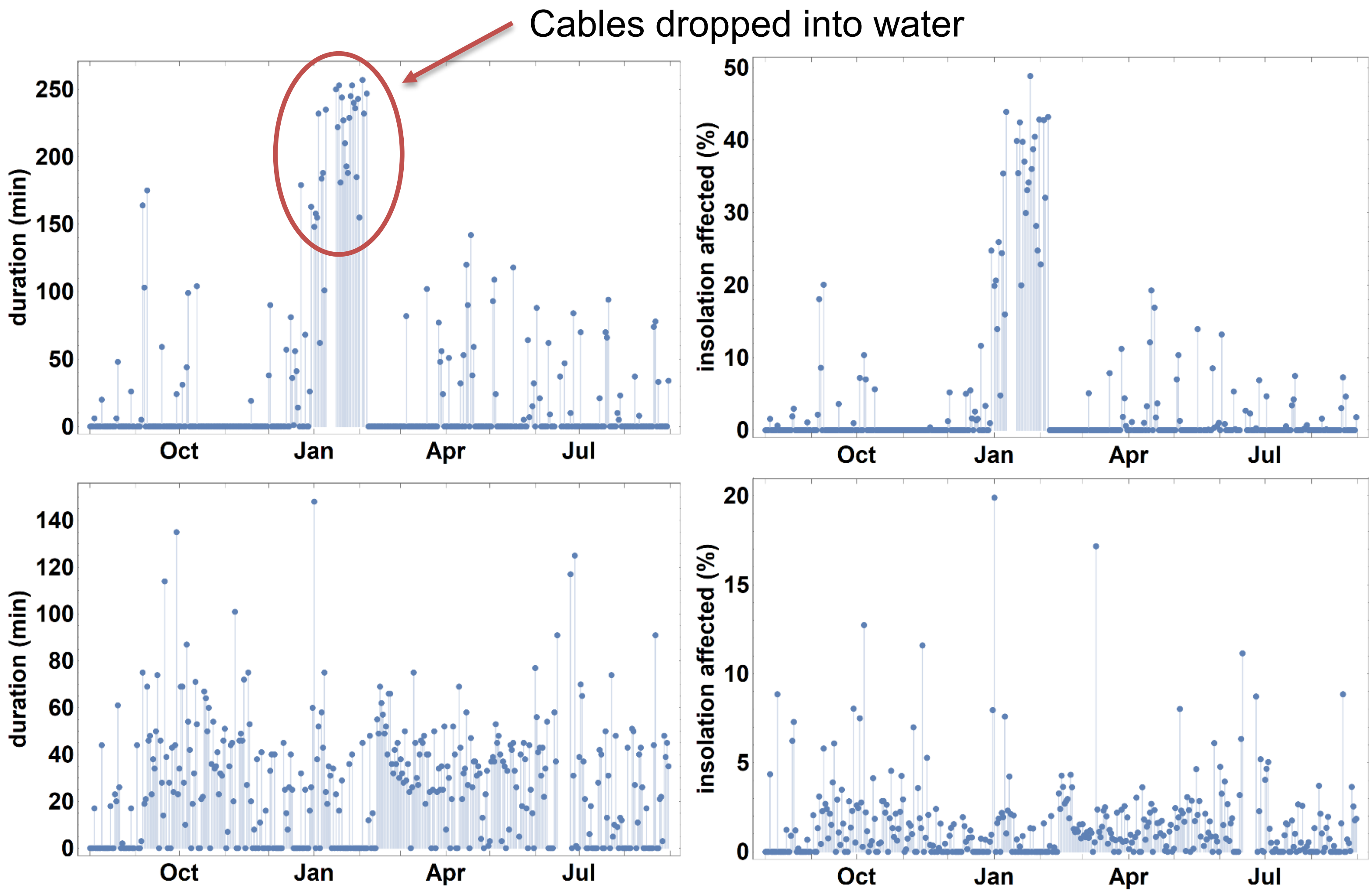


Issue 3: Insulation Resistance

Reduced insulation resistance can lead to power loss

Inverter/ String A

Inverter/ String B



Issue 4: Moisture/water ingress

- ❑ Electrical boxes and cabinets are generally exposed to rain and spill water
- ❑ Constant movement
- ❑ Needs high ratings for Ingress protection (IP65 or above)
- ❑ Keep insects out as well

Water ingress and mild corrosion

Water leakage through cable gland

Issue 5: Vegetation & Biofouling

Leading to additional stress on the cables

Source: © Lightsource BP

Thank you for your attention!
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More information at www.seris.sg

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